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MRL3DPLT DOCUMENTATION – AN INTERFACE PROGRAM FOR THE GENERAL PURPOSE PLOTTING PROGRAM MRLPLT (CRAY-1S VERSION)

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MRL3DPLT DOCUMENT – AN INTERFACE PROGRAM FOR THE GENERAL PURPOSE PLOTTING PROGRAM *MRLPLT* (CRAY–1S VERSION)

by

Y.S. Yu*, A.S. Wong** and N.A.Toews*

ABSTRACT

MRL3DPLT is an interface program to *MRLPLT* which is a general purpose program for graphical representation of data over two–dimensional regions. *MRL3DPLT* consists of two subprograms – *PLTSTRS* and *PLTDSP*. Their basic functions are to convert the 3–D finite element analysis data (**SAPOUT**), generated by the three–dimensional finite element program *SAP3D*, into input data files acceptable to *MRLPLT*.

This report provides information on the file usage, program capabilities and data input instructions. In addition, a simple CRAY–1S Job Control Language (JCL) set up for access to the CRAY–1S supercomputer is given in sections 5 and 6.

Key Words: program, finite element, analysis, graphic, supercomputer

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DOCUMENT MRL3DPLT – PROGRAMME D'INTERFACE A UTILISER AVEC LE PROGRAMME DE TRAÇAGE POLYVALENT MRLPLT (VERSION CRAY–1S)

par

Y.S. Yu*, A.S. Wong** and N.A. Toews*

RÉSUMÉ

Le programme MRL3DPLT est un programme d'interface à utiliser avec le programme MRLPLT, qui est un programme polyvalent permettant de représenter graphiquement des données en deux dimensions. Le programme MRL3DPLT consiste en deux sous–programmes, PLTSTRS et PLTDSP. Ces deux sous–programmes servent essentiellement à convertir les données 3–D d'analyse par la méthode des éléments finis (SAPOUT), fournies par le programme en éléments finis tridimensionnel SAP3D, en fichiers de données d'entrée pour le programme MRLPLT.

Le présent rapport fournit des renseignements sur la façon d'utiliser le fichier, les capacités du programme et l'entrée des données. En outre, un langage de contrôle des travaux (JCL) simple permettant l'accès, au super–ordinateur CRAY–1S est décrit dans les sections 5 et 6.

Mots-clés: programme, éléments finis, analyse, graphique, super–ordinateur

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1.0 INTRODUCTION

MRL3DPLT was originally written for a CDC 6000 computer [1]. It has been modified and enhanced in accordance with the ASCII 77 Fortran Standard, and is now operational on the CRAY–1S supercomputer under the CRAY Operating System (COS).

MRL3DPLT is an interface program to *MRLPLT* [2], a general purpose program for graphical representation of data over 2–D region. The *MRL3DPLT* program consists of two separate sub–programs, namely: *PLTSTRS* and *PLTDSP*. *PLTSTRS* uses element and stress data from the output files (**SAPOUT**) which were created by running the 3–D finite element program *SAP3D* [3], to generate stress point–contour–plot files. The program *PLTDSP* uses the nodal point and nodal displacement data to create vectors plot files.

Using the 3–D finite element output file, **SAPOUT**, and some additional data, both *PLTSTRS* and *PLTDSP* create three distinct files, namely: PLTCMD, PLTIN and PLTBND. These files are the input data files required by *MRLPLT*. The input data requirements of *MRLPLT*, its data structures and plotting capabilities have been described in detail [2].

The input data instructions for *PLTSTRS* and *PLTDSP* are given in Sections 4.1 and 4.2, respectively.

This report provides an overview of the interface program *MRL3DPLT*, in particular, its file usages, its capabilities and plotting options; also its describes input instructions. In addition, a typical input data for sub–programs *PLTSTRS* and *PLTDSP*. A typical Job Control Language (JCL) set up for batch jobs under the Cray Operating System are given in Sections 5 and 6.

2.0 PLOTTING CAPABILITIES

As mentioned above, *PLTSTRS* is capable of producing point-contour plots for both major and minor principal stresses for any "slice" defined in a three–dimensional structure. These stresses are represented at the centroid of each 8–node brick element. In addition to stress point–contours, a safety factor point–contour based on either the Drucker/Prager's failure criterion or Hoek/Brown's empirical failure criterion, can be plotted.

Two types of vector (displacements) plots can be achieved: in–plane displacements and out–of–plane displacements. Example plots of displacements for a simple 3–D models are shown in Figures 13, 14, 15 and 16. Note that the direction of the out–of–plane displacement is perpendicular to the plane.

3.0 FILE USAGE

Eleven logical files including scratch files are used in *MRL3DPLT*. They are listed in Table 1.

Table 1. *MRL3DPLT* File Usage.

No.	Logical File Name	Fortran Alias	Description	MRL3DPLT	
				PLTSTRS	PLTDSP
1.	LNCRD	5	Input data file	Yes	Yes
2.	LLP	6	Print output file	Yes	Yes
3.	LNSAP	7	SAP3D save file	Yes	Yes
4.	PLTIN	8	Plot data file for MRLPLT	Yes	Yes
5.	PLTBND	9	Boundaries files for MRLPLT	Yes	Yes
6.	PLTCMD	10	Plot commands file for MRLPLT	Yes	Yes
7.	DISPLT	11	Temporary scratch file	No	Yes
8.	OUTPLN	12	Temporary scratch file	No	Yes
9.	DIFREF	13	Temporary scratch file	No	Yes
10.	COORD	14	Temporary scratch file	No	Yes
11.	LNSTRS	20	Temporary scratch file	Yes	No

4.0 *MRL3DPLT* INPUT INSTRUCTIONS

As mentioned earlier, *MRL3DPLT* is an interface program for the general purpose plotting routine *MRLPLT*. *MRLPLT* requires three separate input data files, *i.e.*, the input command data file (PLTCMD), the plotting points data file (PLTIN) and the boundary data file (PLTBND). All these files can be created separately by *PLTSTRS* or *PLTDSP*, using the output file **SAPOUT** generated by the *SAP3D* program, in combination with additional input data information.

Because of the nature of input data requirements for point-contours and vectors plots are different (for a three dimensional structure), two separate data input instructions for *PLTSTRS* and *PLTDSP* are given in Tables 2 and 3, respectively.

4.1 *PLTSTRS* Input Instructions

The input data required by *PLTSTRS* are divided into 7 groups, namely:

(a) Problem identification and control data,

(b) Boundary data file(s), if required,

(c) Plot data specification,

(d) Material properties of rock formation,

(e) Individual plot control parameter,

(f) Section–boundary file specification record, if required, and,

(g) Plot area record.

The details of the input data are given in the following tables (Tables 2a to 2f).

Table 2a

Group (a) – Problem Identification and Control Data:		
Variable(s)	**Variable Definition or Description**	**Format**
Record No. 1 – Problem title information:		
ID	80 characters problem title information.	A80
Record No. 2 – Plot Control Parameter Data:		
PLTWID	Width of plot paper in inches. (Default is 29)	F10.0
BWIDTH	Width of plot border in inches. (Default is 2)	F10.0
XLNGTH	Limit of plot X–axis (horizontal) in inches. (Default is 40)	F10.0
YLNGTH	Limit of plot Y–axis (vertical) in inches.	F10.0
	(Default is PLTWID − 2.0 × BWIDTH − 0.4)	F10.0
NLINES	Number of lines of plot title.	I5
NBND	Number of boundary files: If > 0 No boundary input data; If = 0 Fatal error; If > 0 Boundary files already exist.	I5
Record No. 3 – Plot Title If NLINES ≠ 0:		
TITLE	NLINES of plot title or identification.	A80
Group (b) – Boundary Data File(s) If NBND > 0:		
Record No. 1 – Block of Boundary Data†:		
YCORD	Boundary data point of Y–coordinate.	F10.0
ZCORD	Boundary data point of Z–coordinate.	F10.0
NCODE	Plotter pen control parameter: = 2 Draw a solid line (pen down); = 3 No line to be drawn (pen up); = 4 Draw a dash line (pen down).	I5
Remarks: † – Each individual set of boundary file is separated by an end-of-file record.		

Table 2b

Group (c) – Plot Data Specification:		
Variable(s)	**Variable Definition or Description**	**Format**
Record No. 1 – Plot Data Specification:		
PRIME	Plot type indicator. (Default is PNTCNT)	A6
NPROB	Number of sets of plot data.	I5
IPNT	Stress point contours plot indicator: = 1 Major principal stresses; = 2 Minor principal stresses; = 3 Intermediate principal stresses; = 4 Drucker/Prager's yield criterion; = 5 Major principal strains; = 6 Minor principal strains; = 7 Intermediate principal strains; = 8 Volume dilatation; = 9 Hoek/Brown's empirical failure criterion; > 9 User defined stress function.	I5
Remarks:		

Table 2c

Group (d) – Material Properties of Rock Formations:
If IPNT = 4 skip to (A);
If IPNT = 5, 6, 7 and 8 skip to (B);
If IPNT = 9 skip to (C).

Variable(s)	Variable Definition or Description	Format
(A) Record No. 1 – Material Properties For IPNT = 4:		
MATNUM	Number of material properties record(s). (Maximum = 30)	I5
(A) Record No. 2 – Block of MATNUM Material Properties Data:		
COHES	Cohesive strength of material.	E15.7
PHI	Angle of internal friction in degrees.	E15.7
(B) Record No. 1 – Material Properties For IPNT = 5,6,7,8:		
MATNUM	Number of material properties record(s). (Maximum = 30)	I5
(B) Record No. 2 – Block of MATNUM Material Properties Data:		
E	Young's modulus or modulus of deformation.	E15.7
XNU	Poisson's ratio.	E15.7
(C) Record No. 1 – Material Properties For IPNT = 9:		
MATNUM	Number of material properties record(s). (Maximum = 30)	I5
(C) Record No. 2 – Block of MATNUM Material Properties Data:		
QU	Uniaxial compressive strength of intact rock.	E15.7
XXM	Hoek/Brown's empirical constant m.	F10.0
XXS	Hoek/Brown's empirical constant s.	F10.0

Remarks:

Table 2d

Group (e) – Individual Plot Control Parameter:		
Variable(s)	**Variable Definition or Description**	**Format**
Record No. 1 – Plot Control Parameter:		
NUMSUB	Number of individual plot(s) to be performed.	I5
ISUB	Element slice–boundary file association index: < 0 All sections to be plotted. IABS(ISUB) is the numbers of X coordinate–boundary file association records to be read. All the sections are given file association IDEFB number. $= 0$ All sections to be done using IDEFB boundary file. > 0 Only those sections with X–coordinates are given on the ISUB number of boundary file will be done.	I5
IDEFB	Default boundary file number. (If IDEFB ≤ 0; IDEFB = 1)	I5
ISLCT	Data selection number. (Default is 1)	I5
IRECT	Magnification indicator: $= 0$ No plot magnification; $\neq 0$ Plot will be magnified according to specify limits of Y and Z–coordinates	I5

ICNT	Contour interval specification indicator:
	< 0 Both $CONTOURS and IABS(ICNT) number of $CONTOUR labelled records are to be written on logical unit 10. The two types of contour interval specification must not interfere with one another. Below is shown a valid combination.
	`$CONTOURS 100.0 3 -500.0 0.0`
	`$CONTOUR -700.0 -500.0`
	`$CONTOUR 0.0 50.0`
	$= 0$ Only a $CONTOURS record is to be generated.
		I5

Remarks:		

Table 2e

Group (f) – Section–Boundary File Specification Record If ISUB $\neq$ 0:		
Variable(s)	**Variable Definition or Description**	**Format**
Record No. 1 – ISUB of Section–Boundary File Specification data:		
NSLICE	Slice number.	I5
NB1	Associated section–boundary file number. (Default is IDEFB)	I5
Group (g) – Plot Contour Interval Information: If ICNT > 0 skip to (A); If ICNT = 0 skip to (B).		
(A) Record No. 1 – General Plot Contour:		
CNTINT†	Contour interval ranging from minimum to maximum data value.	F10.0
MMREAD	Plot data limit indicator: = 0 Use data limits as found on data file; = 1 Use data file upper limit (DMAX) and input lower data limit (ZMIN); = 2 Input upper data limit (ZMAX) and use data file data limit (DMIN); = 3 Input both upper and lower data limits.	I5
ZMIN	Lower data limit.	F10.0
ZMAX	Upper data limit.	F10.0
(B) Record No. 1 – Individual Plot Contour:		
CMIN	Lower data limit of single contour interval.	F10.0
CMAX	Upper data limit of single contour interval.	F10.0
Remarks: † – If total number of contours is < 5, CNTINT will be redefined.		

Table 2f

Group (g) – Plot Area Record If IRECT $\neq$ 0:		
Variable(s)	Variable Definition or Description	Format
Record No. 1 – Plot Region Limits Data:		
BYMINR	Minimum value of Y–coordinate.	F10.0
BYMAXR	Maximum value of Y–coordinate.	F10.0
BZMINR	Minimum value of Z–coordinate.	F10.0
BZMAXR	Maximum value of Z–coordinate.	F10.0
Remarks:		

4.2 *PLTDSP* Input Instructions

The input data required by *PLTDSP* are divided into 6 groups, namely:

(a) Problem identification and control data,

(b) Boundary data file(s), if required,

(c) Plot data specification,

(d) Plot scale factor,

(e) Section–boundary file specification record, if required, and,

(f) Plot area record.

The details of the input data are given in the following tables (Tables 3a to 3c).

Table 3a

Group (a) – Problem Identification and Control Data:		
Variable(s)	**Variable Definition or Description**	**Format**
Record No. 1 – Problem Title Information:		
ID	80 characters problem title information.	A80
Record No. 2 – Plot Control Parameter Data:		
PLTWID	Width of plot paper in inches. (Default is 29)	F10.0
BWIDTH	Width of plot border in inches. (Default is 2)	F10.0
XLNGTH	Limit of plot X–axis (horizontal) in inches. (Default is 40)	F10.0
YLNGTH	Limit of plot Y–axis (vertical) in inches.	F10.0
	(Default is PLTWID − 2.0 × BWIDTH − 0.4)	F10.0
NLINES	Number of lines of plot title.	I5
NBND	Number of boundary files: > 0 No boundary input data; $= 0$ Fatal error; > 0 Boundary files already exist.	I5
Record No. 3 – Plot Title If NLINES $\neq 0$:		
TITLE	NLINES of Plot title or identification.	A80
Group (b) – Boundary Data File(s) If NBND > 0:		
Record No. 1 – NBND Blocks of Boundary Data†:		
YCORD	Boundary data point of Y–coordinate.	F10.0
ZCORD	Boundary data point of Z–coordinate.	F10.0
NCODE	Plotter pen control parameter: $= 2$ Draw a solid line (pen down); $= 3$ No line to be drawn (pen up); $= 4$ Draw a dash line (pen down).	I5
Remarks: † – Each individual set of boundary file is separated by an end-of-file record.		

Table 3b

Group (c) – Plot Data Specification:

Variable(s)	Variable Definition or Description	Format
Record No. 1 – Plot Data Specification:		
NPROB	Data subproblem number. (referring to NC as defined in the first displacement data files record)	I5
REFPRD	Subproblem Reference Number: = 0 NPROB of "absolute" displacements to be plotted; > 0 NPROB of "differential" displacements with respect to REFPRD to be plotted.	I5
INDCRD	Section–boundary indicator: > 0 For the number of section-boundary file association records following which specify sections to be plotted. = 0 For all sections to be plotted using section–boundary file number IDEFB. < 0 Input section–boundary file association records if all sections are to be plotted with IABS(INDCRD) number.	I5
IDEFB	Default boundary file number. (If IDEFB $\leq$ 0; IDEFB = 1)	I5
ISECT	Data selection number. (Default is 1)	I5
IRECT	Specified plot region magnification indicator: = 0 No plot magnification; $\neq$ 0 Plot will be magnified according to specify limits of Y and Z–coordinates.	I5
IDX	Out-of-plane plot indicator: > 0 SCLX is adjusted by the factor of 2 such that the plotted length of XMAX lies between .75 and 1.5 inches. = 0 Plot if plotted length of XMAX is > 0.1 inch. < 0 Ignore out–of–plane displacements plot.	I5

Remarks:

Absolute – Only the NPROB displacement file is used.

Differential – The NPROB with respect to REFPRB displacement file is used.

Table 3c

Group (d) – Plot Scale Factor: (Mandatory But May Use Default Value)		
Variable(s)	**Variable Definition or Description**	**Format**
Record No. 1 – Scale Factor:		
SCLYZ	Scale factor for in-plane plots. (Default is YZMAX = 1 inch)	F10.0
SCLX	Scale factor for out-of-plane plots. (Default is SCLX = SCLYZ)	F10.0
Group (e) – Section–Boundary File Specification Records If INDCRD $\neq$ 0:		
Record No. 1 – INDCRD of Section–Boundary File Specification data:		
NSCTN	Section number.	I5
NB1	Associated section–boundary file number. (Default is IDEFB)	I5
Group (f) – Plot Area Record If IRECT $\neq$ 0:		
Record No. 1 – Plot Region Limits Data:		
BYMIN	Minimum value of Y–coordinate. (horizontal axis)	F10.0
BYMAX	Maximum value of Y–coordinate.	F10.0
BZMIN	Minimum value of Z–coordinate. (vertical axis)	F10.0
BZMAX	Maximum value of Z–coordinate.	F10.0
Remarks:		

5.0 *PLTSTRS* EXAMPLE

An example of 3–D input data is shown in Figure 1 (including CRAY–1S COS JCL) for *PLTSTRS*. The isometric view of this example has been described in detail [4]. Figures 2, 3 and 4 indicate the three typical output files (*i.e.*, **PLTCMD, PLTIN** and **PLTBND**) of the example that created by *PLTSTRS*. Figures 5, 6, 7 and 8 show point–contour plots for major principal stress, minor principal stress, Drucker/Prager's yield criterion and Hoek/Brown's empirical failure criterion on section X = 102.5 m for the example.

Note that the continuum mechanics sign convention (tensile stress positive and compressive stress negative) is used in the finite element program *SAP3D*. However, in mining applications, the convention is just reversed. To achieve this, the stresses are reversed in sign during the execution of *PLTSTRS*.

```
JOB,JN=REPORT,T=500,MFL=400000.                    <CRAY-1S job card
ACCOUNT,AC=GEMRYYU,US=GEMRYYU,UPW=WONG.            <CRAY-1S account card>
ACCESS,DN=PLTSTRS,PDN=PLTSTRS,ID=MRL.              <PLTSTRS object library>
ACCESS,DN=SAPOUT,PDN=REPORTSAPOUT,ID=WONG.         <SAP3D saved file - SAPOUT>
OPTION,STAT=ON.
PLTSTRS.                                           <Execute PLTSTRS>
REWIND,DN=PLTCMD.
SAVE,DN=PLTCMD,PDN=ELE5000CMD,ID=WONG.             <Save PLTCMD file>
REWIND,DN=PLTBND.
SAVE,DN=PLTBND,PDN=ELE5000BND,ID=WONG.             <Save PLTBND file>
REWIND,DN=PLTIN.
SAVE,DN=PLTIN,PDN=ELE5000IN,ID=WONG.               <Save PLTIN file>
EXIT.                                              <Exit form CRAY-1S>
/EOF                                               <CRAY-1S end-of-file mark>
MY NAME   MY ADDRESS                               <Problem title information>
     11.0       0.5       9.0       6.0    3    2 <Plot control parameter data>
SAP3D MODEL SIMULATION (5000 ELEMENTS)             <Plot title # 1>
MAJOR/MINOR PRINCIPAL STRESS, DRUCKER/PRAGER &     <Plot title # 2>
HOEK/BROWN CONTOUR PLOTS                           <Plot title #3>
      0.0       0.0       3                     _|
    300.0       0.0       2                      |
    300.0     300.0       2                       > <Boundary file # 1>
      0.0     300.0       2                      |
      0.0       0.0       2                     _|
/EOF                                               <CRAY-1S end-of-file mark>
```

Figure 1. *PLTSTRS* CRAY–1S JCL and input data of the 3–D example.

- Figure 1 continued -

```
      0.0       0.0       3                                  ┐
    300.0       0.0       2                                  │
    300.0     300.0       2                                  │
      0.0     300.0       2                                  │
      0.0       0.0       2                                  │
    170.0     140.0       3                                  │
    240.0     140.0       2                                  │
    240.0     222.0       2                                  ├> <Boundary file # 2>
    170.0     222.0       2                                  │
    170.0     140.0       2                                  │
    264.0     152.0       3                                  │
    288.0     152.0       2                                  │
    288.0     240.0       2                                  │
    264.0     240.0       2                                  │
    264.0     152.0       2                                  ┘
/EOF                                                        <CRAY-1S end-of-file mark>
PNTCNT        1    1                                        <Plot data specification>
    1    1    1    1    1    0                             <Plot control parameter>
    8    2                                                  <Section-boundary data>
      0.5    0                                             <Individual plot contour>
    140.0     300.0     100.0     300.0                     <Plot region limits data>
PNTCNT        1    2
    1    1    1    1    1    0
    8    2
      0.5    0
    140.0     300.0     100.0     300.0
PNTCNT        1    4
    3                                                      <Number of material data>
      2.0       40.0                                       <# 1 COHEC and PHI>
      2.0       40.0                                       <# 2 COHEC and PHI>
      2.0       40.0                                       <# 3 COHEC and PHI>
    1    1    1    1    1    0
    8    2
      0.5    0
    140.0     300.0     100.0     300.0
PNTCNT        1    9
    3                                                      <Number of material data>
     45.0       3.30     0.1111                           <# 1 QU m s>
     45.0       3.30     0.1111                           <# 2 QU m s>
     45.0       3.30     0.1111                           <# 3 QU m s>
    1    1    1    1    1    0
    8    2
      0.5    0
    140.0     300.0     100.0     300.0
```

```
$DATASET      4
$BNDRYSET     2
$IDENT    <my name> <my address>
$TITLE        3
SAP3D MODEL SIMULATION (5000 ELEMENTS)
MAJOR/MINOR PRINCIPAL STRESS, DRUCKER/PRAGER &
HOEK/BROWN CONTOUR PLOTS
*PNTCNT
$DATA         1    1
$DATAFMT  (1X,3E15.7)
$BNDRY        2
$BNDRYFMT (1X,2E15.7,I5)
$PLOTAREA 0.9000E+010.6000E+010.1400E+030.3000E+030.1000E+030.3000E+03
$CONTOURS 0.5000E+00          30.6362E+000.1312E+02
$LABEL        1
MAJOR PRINCIPAL STRESS CONTOURS FOR SECTION X = 102.5 M.
*PNTCNT
$DATA         2    1
$DATAFMT  (1X,3E15.7)
$BNDRY        2
$BNDRYFMT (1X,2E15.7,I5)
$PLOTAREA 0.9000E+010.6000E+010.1400E+030.3000E+030.1000E+030.3000E+03
$CONTOURS 0.5000E+00          3-.1023E+010.5254E+01
$LABEL        1
MINOR PRINCIPAL STRESS CONTOURS FOR SECTION X = 102.5 M.
*PNTCNT
$DATA         3    1
$DATAFMT  (1X,3E15.7)
$BNDRY        2
$BNDRYFMT (1X,2E15.7,I5)
$PLOTAREA 0.9000E+010.6000E+010.1400E+030.3000E+030.1000E+030.3000E+03
$CONTOURS 0.5000E+00          30.1375E+010.1000E+02
$LABEL        1
DRUCKER/PRAGER YIELD CRITERION FOR SECTION X = 102.5 M.
*PNTCNT
$DATA         4    1
$DATAFMT  (1X,3E15.7)
$BNDRY        2
$BNDRYFMT (1X,2E15.7,I5)
$PLOTAREA 0.9000E+010.6000E+010.1400E+030.3000E+030.1000E+030.3000E+03
$CONTOURS 0.5000E+00          30.1318E+010.1000E+02
$LABEL        1
HOEK & BROWN'S EMPIRICAL FAILURE CRITERION FOR SECTION X = 102.5 M.
**
```

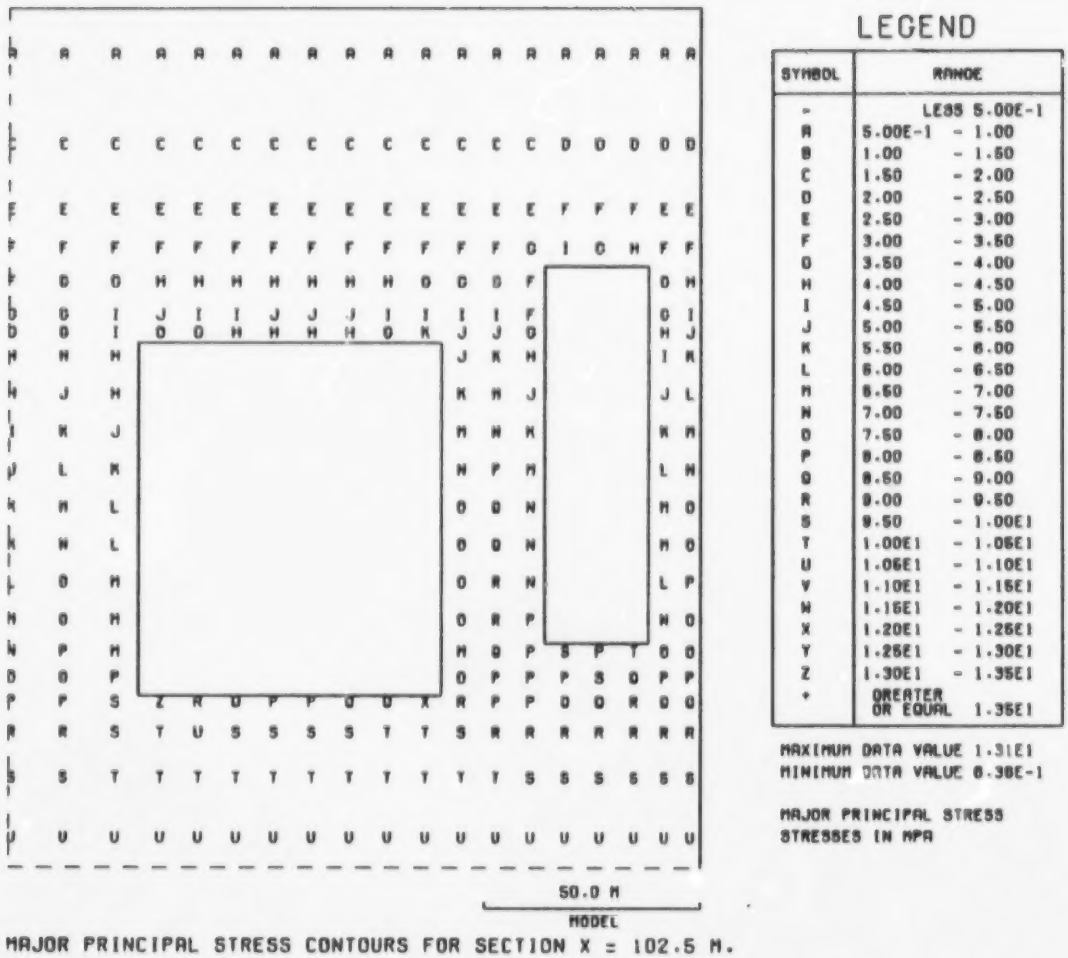
Figure 2. PLTCMD file of the 3–D example generated by *PLTSTRS*.

```
                                                    <file #1>
   0.1400000E+03  0.1058750E+03  0.1062593E+02
   0.1520000E+03  0.1058750E+03  0.1066593E+02
   0.1640000E+03  0.1058750E+03  0.1072477E+02
   0.1743750E+03  0.1058750E+03  0.1078132E+02
   0.1831250E+03  0.1058750E+03  0.1086977E+02
   0.1918750E+03  0.1058750E+03  0.1091965E+02
   0.2006250E+03  0.1058750E+03  0.1095334E+02
   . . . .
   . . . .
   0.2910000E+03  0.2880000E+03  0.7960037E+00
   0.2970000E+03  0.2880000E+03  0.7943067E+00
<ctrl_Z>  (end-of-file mark)                 <file # 2>
   0.1400000E+03  0.1058750E+03  0.5234109E+01
   0.1520000E+03  0.1058750E+03  0.5253878E+01
   0.1640000E+03  0.1058750E+03  0.5251140E+01
   0.1743750E+03  0.1058750E+03  0.5184974E+01
   0.1831250E+03  0.1058750E+03  0.5082960E+01
   0.1918750E+03  0.1058750E+03  0.4963828E+01
   0.2006250E+03  0.1058750E+03  0.4882543E+01
   . . . .
   . . . .
   0.2910000E+03  0.2880000E+03  0.3367618E+00
   0.2970000E+03  0.2880000E+03  0.3297297E+00
<ctrl_Z>  (end-of-file mark)                 <file # 3>
   0.1400000E+03  0.1058750E+03  0.3629691E+01
   0.1520000E+03  0.1058750E+03  0.3629163E+01
   0.1640000E+03  0.1058750E+03  0.3602478E+01
   0.1743750E+03  0.1058750E+03  0.3528019E+01
   0.1831250E+03  0.1058750E+03  0.3415221E+01
   0.1918750E+03  0.1058750E+03  0.3312540E+01
   . . . .
   . . . .
   0.2910000E+03  0.2880000E+03  0.1000000E+02
   0.2970000E+03  0.2880000E+03  0.1000000E+02
<ctrl_Z>  (end-of-file mark)                 <file # 4>
   0.1400000E+03  0.1058750E+03  0.3471915E+01
   0.1520000E+03  0.1058750E+03  0.3465092E+01
   0.1640000E+03  0.1058750E+03  0.3445228E+01
   0.1743750E+03  0.1058750E+03  0.3406609E+01
   0.1831250E+03  0.1058750E+03  0.3347327E+01
   0.1918750E+03  0.1058750E+03  0.3295130E+01
   0.2006250E+03  0.1058750E+03  0.3259753E+01
   . . . .
   . . . .
   0.2910000E+03  0.2880000E+03  0.1000000E+02
   0.2970000E+03  0.2880000E+03  0.1000000E+02
```

Figure 3. Partial PLTIN file of the 3–D example generated by *PLTSTRS*.

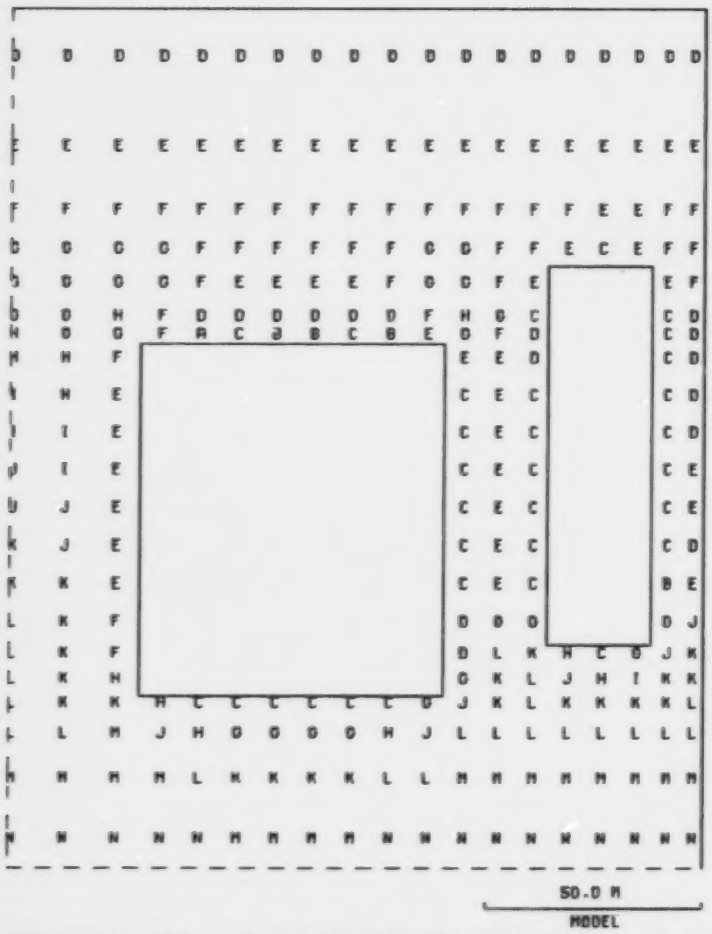
```
   0.0000000E+00  0.0000000E+00    3
   0.3000000E+03  0.0000000E+00    2
   0.3000000E+03  0.3000000E+03    2
   0.0000000E+00  0.3000000E+03    2
   0.0000000E+00  0.0000000E+00    2
<ctrl_Z>  (end-of-file mark)
   0.0000000E+00  0.0000000E+00    3
   0.3000000E+03  0.0000000E+00    2
   0.3000000E+03  0.3000000E+03    2
   0.0000000E+00  0.3000000E+03    2
   0.0000000E+00  0.0000000E+00    2
   0.1700000E+03  0.1400000E+03    3
   0.2400000E+03  0.1400000E+03    2
   0.2400000E+03  0.2220000E+03    2
   0.1700000E+03  0.2220000E+03    2
   0.1700000E+03  0.1400000E+03    2
   0.2640000E+03  0.1520000E+03    3
   0.2880000E+03  0.1520000E+03    2
   0.2880000E+03  0.2400000E+03    2
   0.2640000E+03  0.2400000E+03    2
   0.2640000E+03  0.1520000E+03    2
```

Figure 4. PLTBND file of the 3–D example generated by *PLTSTRS*.



MAJOR PRINCIPAL STRESS CONTOURS FOR SECTION X = 102.5 M.

Figure 5. Major principal stress point contours plot for section X=102.5 m.



LEGEND

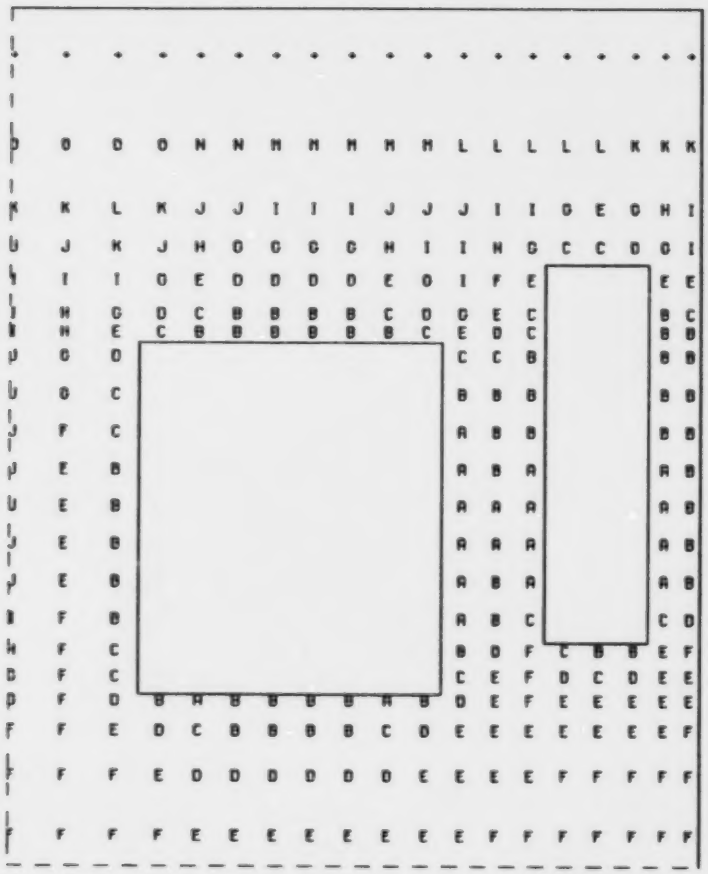
SYMBOL	RANGE
-	LESS -1.50
A	-1.50 - -1.00
B	-1.00 - -5.00E-1
C	-5.00E-1 - 0.0
D	0.0 - 5.00E-1
E	5.00E-1 - 1.00
F	1.00 - 1.50
G	1.50 - 2.00
H	2.00 - 2.50
I	2.50 - 3.00
J	3.00 - 3.50
K	3.50 - 4.00
L	4.00 - 4.50
M	4.50 - 5.00
N	5.00 - 5.50
+	GREATER OR EQUAL 5.50

MAXIMUM DATA VALUE 6.26
MINIMUM DATA VALUE -1.02

MINOR PRINCIPAL STRESS
STRESSES IN MPA

MINOR PRINCIPAL STRESS CONTOURS FOR SECTION X = 102.5 M.

Figure 6. Minor principal stress point contours plot for section X=102.5 m.



DRUCKER/PRAGER YIELD CRITERION FOR SECTION X = 102.5 M.

LEGEND

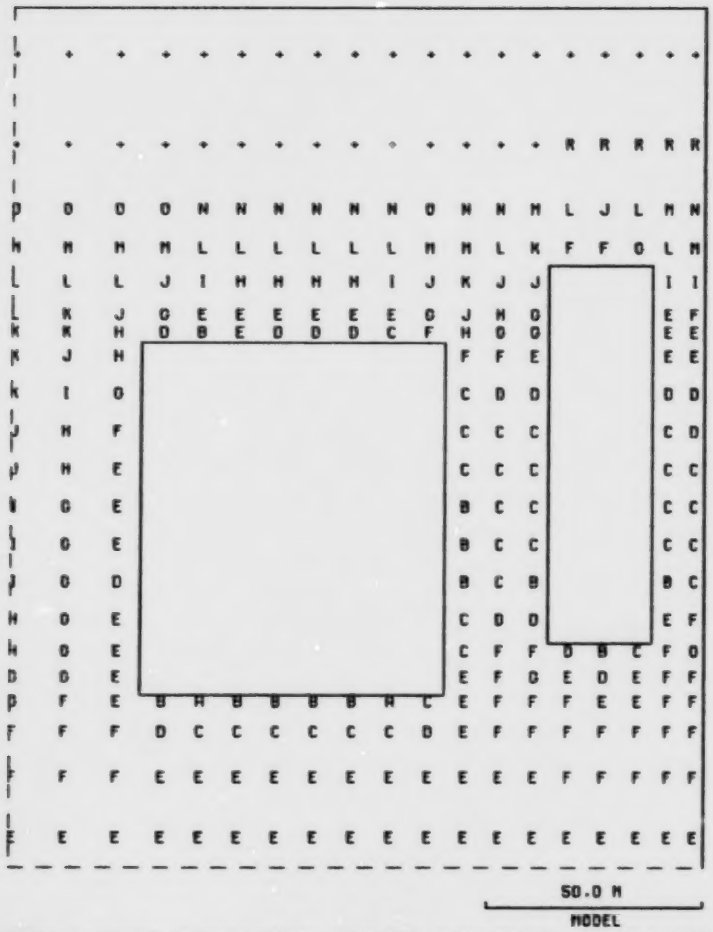
SYMBOL	RANGE
-	LESS 1.00
A	1.00 - 1.50
B	1.50 - 2.00
C	2.00 - 2.50
D	2.50 - 3.00
E	3.00 - 3.50
F	3.50 - 4.00
G	4.00 - 4.50
H	4.50 - 5.00
I	5.00 - 5.50
J	5.50 - 6.00
K	6.00 - 6.50
L	6.50 - 7.00
M	7.00 - 7.50
N	7.50 - 8.00
O	8.00 - 8.50
P	8.50 - 9.00
Q	9.00 - 9.50
R	9.50 - 1.00E1
*	GREATER OR EQUAL 1.00E1

MAXIMUM DATA VALUE 1.00E1
MINIMUM DATA VALUE 1.37

DRUCKER/PRAGER

COHEC (MPA)	PHI (DEG.)
2.0	40.0
2.0	40.0
2.0	40.0

Figure 7. Drucker/Prager point contours plot for section X=102.5 m.



LEGEND

SYMBOL	RANGE
-	LESS 1.00
A	1.00 - 1.50
B	1.50 - 2.00
C	2.00 - 2.50
D	2.50 - 3.00
E	3.00 - 3.50
F	3.50 - 4.00
G	4.00 - 4.50
H	4.50 - 5.00
I	5.00 - 5.50
J	5.50 - 6.00
K	6.00 - 6.50
L	6.50 - 7.00
M	7.00 - 7.50
N	7.50 - 8.00
O	8.00 - 8.50
P	8.50 - 9.00
Q	9.00 - 9.50
R	9.50 - 1.00E1
*	GREATER OR EQUAL 1.00E1

MAXIMUM DATA VALUE 1.00E1
MINIMUM DATA VALUE 1.32

HOEK/BROWN

M	S	QU (MPA)
3.3000	0.1111	45.0
3.3000	0.1111	45.0
3.3000	0.1111	45.0

HOEK & BROWN'S EMPIRICAL FAILURE CRITERION FOR SECTION X = 102.5 M.

Figure 8. Hoek/Brown point contours plot for section X=102.5 m

6.0 *PLTDSP* EXAMPLE

Figure 9 shows the displacements plot of the 3–D example input data (in cluding CRAY–1S COS JCL) for *PLTDSP*. Figure 10, 11 and 12 show the three typical output files (*i.e.*, PLTCMD, PLTIN and PLTBND) that created by the *PLTDSP*. Figure 13, 14, 15 and 16 shown both in–plane and out-of-plane vectors (displacements) plots for section X = 99 m and section X = 79 m of the example.

```
JOB,JN=REPORT,T=500,MFL=400000.                          <CRAY-1S job card>
ACCOUNT,AC=GEMRYYU,US=GEMRYYU,UPW=WONG.                  <CRAY-1S account card>
ACCESS,DN=PLTDSP,PDN=PLTDSP,ID=MRL.                      <PLTDSP object library>
ACCESS,DN=SAPOUT,PDN=REPORTSAPOUT,ID=WONG.               <SAP3D saved file - SAPOUT>
OPTION,STAT=ON.
PLTDSP.                                                  <Execute PLTDSP>
REWIND,DN=PLTCMD.
SAVE,DN=PLTCMD,PDN=ELE5000CMDD,ID=WONG.                  <Save PLTCMD file>
REWIND,DN=PLTBND.
SAVE,DN=PLTBND,PDN=ELE5000BNDD,ID=WONG.                  <Save PLTBND file>
REWIND,DN=PLTIN.
SAVE,DN=PLTIN,PDN=ELE5000IND,ID=WONG.                    <Save PLTIN file>
EXIT.                                                    <Exit from CRAY-1S>
/EOF                                                     <CRAY-1S end-of-file mark>
MY NAME   MAY ADDRESS                                    <Problem title information>
     11.0       0.5       9.0       6.0    2    2 <Plot control parameter data>
SAP3D MODEL SIMULATION (5000 ELEMENTS)                   <Plot title # 1>
ABSOLUTE DISPLACEMENT PLOTS ONLY                         <Plot title # 2>
      0.0       0.0       3                          ┐
    300.0       0.0       2                          |
    300.0     300.0       2                          > <Boundary file # 1>
      0.0     300.0       2                          |
      0.0       0.0       2                          ┘
/EOF                                                     <CRAY-1S end-of-file mark>
      0.0       0.0       3                          ┐
    300.0       0.0       2                          |
    300.0     300.0       2                          |
      0.0     300.0       2                          |
      0.0       0.0       2                          |
    170.0     140.0       3                          |
    240.0     140.0       2                          |
    240.0     222.0       2                          > <Boundary file # 2>
    170.0     222.0       2                          |
    170.0     140.0       2                          |
    264.0     152.0       3                          |
    288.0     152.0       2                          |
    288.0     240.0       2                          |
    264.0     240.0       2                          |
    264.0     152.0       2                          ┘
/EOF                                                     <CRAY-1S end-of-file mark>
    1    0    2    1    1    1    0                    <Plot data specification>
      0.0       0.0                                    <Plot scale factor>
    5    1                                            <Section-boundary #1>
    8    2                                            <Section-boundary #2>
     140.0     300.0     100.0     300.0               <Plot region limits data>
```

Figure 9. *PLTDSP* CRAY–1S JCL and input data of the 3–D Example.

```
$DATASET      4
$BNDRYSET     2
$IDENT    MY NAME   MY ADDRESS
$TITLE        2
SAP3D MODEL SIMULATION (5000 ELEMENTS)
ABSOLUTE DISPLACEMENT PLOTS ONLY
*VECTOR
$DATA         1    1
$DATAFMT  (5X,4E15.7)
$BNDRY        1
$PLOTAREA         9.        6.      140.      300.      100.      300.
$SCALE       0.00500
$LABEL        1
IN-PLANE DISPLACEMENTS FOR SECTION X =  79 M.
*VECTOR
$DATA         2    1
$DATAFMT  (5X,4E15.7)
$BNDRY        1
$PLOTAREA         9.        6.      140.      300.      100.      300.
$SCALE       0.00500
$LABEL        1
OUT-OF-PLANE DISPLACEMENTS FOR SECTION X =  79 M.
*VECTOR
$DATA         7    1
$DATAFMT  (5X,4E15.7)
$BNDRY        2
$PLOTAREA         9.        6.      140.      300.      100.      300.
$SCALE       0.00500
$LABEL        1
IN-PLANE DISPLACEMENTS FOR SECTION X =  99 M.
*VECTOR
$DATA         8    1
$DATAFMT  (5X,4E15.7)
$BNDRY        2
$PLOTAREA         9.        6.      140.      300.      100.      300.
$SCALE       0.00500
$LABEL        1
OUT-OF-PLANE DISPLACEMENTS FOR SECTION X =  99 M.
**
```

Figure 10. PLTCMD file of the 3–D example generated by *PLTDSP*.

```
                                                                    <file # 1>
 6080  0.3000000E+03  0.3000000E+03  0.0000000E+00 -0.7374483E-04
 6071  0.2940000E+03  0.3000000E+03  0.2022439E-04 -0.7432430E-04
 6062  0.2880000E+03  0.3000000E+03  0.4026113E-04 -0.7717122E-04
 6053  0.2800000E+03  0.3000000E+03  0.6641510E-04 -0.8307719E-04
 6044  0.2720000E+03  0.3000000E+03  0.9209655E-04 -0.9149560E-04
 6035  0.2640000E+03  0.3000000E+03  0.1172707E-03 -0.1020135E-03
 6026  0.2560000E+03  0.3000000E+03  0.1423414E-03 -0.1143296E-03
. . . .
. . . .
   14  0.3976000E+02  0.0000000E+00  0.8302049E-04  0.0000000E+00
    5  0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00
<ctrl_Z>  (end-of-file mark)                                        <file # 2>
 6080  0.3000000E+03  0.3000000E+03  0.0000000E+00 -0.9299438E-04
 6071  0.2940000E+03  0.3000000E+03  0.0000000E+00 -0.9276597E-04
 6062  0.2880000E+03  0.3000000E+03  0.0000000E+00 -0.9218273E-04
 6053  0.2800000E+03  0.3000000E+03  0.0000000E+00 -0.9061234E-04
 6044  0.2720000E+03  0.3000000E+03  0.0000000E+00 -0.8833421E-04
 6035  0.2640000E+03  0.3000000E+03  0.0000000E+00 -0.8542831E-04
 6026  0.2560000E+03  0.3000000E+03  0.0000000E+00 -0.8184187E-04
 . . . .
 . . . .
   14  0.3976000E+02  0.0000000E+00  0.0000000E+00 -0.1056727E-05
    5  0.0000000E+00  0.0000000E+00  0.0000000E+00 -0.7007218E-06
<ctrl_Z>  (end-of-file mark)                                        <file # 3>
 6083  0.3000000E+03  0.3000000E+03  0.0000000E+00  0.1394555E-04
 6074  0.2940000E+03  0.3000000E+03  0.2211599E-04  0.1914047E-04
 6065  0.2880000E+03  0.3000000E+03  0.4198464E-04  0.8534627E-05
 6056  0.2800000E+03  0.3000000E+03  0.7013224E-04  0.5153795E-05
 6047  0.2720000E+03  0.3000000E+03  0.9605575E-04 -0.4573647E-05
 6038  0.2640000E+03  0.3000000E+03  0.1226803E-03 -0.1843788E-04
 6029  0.2560000E+03  0.3000000E+03  0.1465961E-03 -0.2687789E-04
. . . .
. . . .
   17  0.3976000E+02  0.0000000E+00  0.8256302E-04  0.0000000E+00
    8  0.0000000E+00  0.0000000E+00  0.0000000E+00  0.0000000E+00
<ctrl_Z>  (end-of-file mark)                                        <file # 4>
 6083  0.3000000E+03  0.3000000E+03  0.0000000E+00 -0.2891394E-04
 6074  0.2940000E+03  0.3000000E+03  0.0000000E+00 -0.2882698E-04
 6065  0.2880000E+03  0.3000000E+03  0.0000000E+00 -0.2867975E-04
 6056  0.2800000E+03  0.3000000E+03  0.0000000E+00 -0.2760651E-04
 6047  0.2720000E+03  0.3000000E+03  0.0000000E+00 -0.2690367E-04
 6038  0.2640000E+03  0.3000000E+03  0.0000000E+00 -0.2651824E-04
 6029  0.2560000E+03  0.3000000E+03  0.0000000E+00 -0.2524589E-04
. . . .
. . . .
   17  0.3976000E+02  0.0000000E+00  0.0000000E+00 -0.3056273E-06
    8  0.0000000E+00  0.0000000E+00  0.0000000E+00 -0.2022972E-06
```

Figure 11. Partial PLTIN file of the 3–D example generated by *PLTDSP*.

```
   0.0000000E+00  0.0000000E+00    3
   0.3000000E+03  0.0000000E+00    2
   0.3000000E+03  0.3000000E+03    2
   0.0000000E+00  0.3000000E+03    2
   0.0000000E+00  0.0000000E+00    2
<ctrl_Z>  (end-of-file mark)
   0.0000000E+00  0.0000000E+00    3
   0.3000000E+03  0.0000000E+00    2
   0.3000000E+03  0.3000000E+03    2
   0.0000000E+00  0.3000000E+03    2
   0.0000000E+00  0.0000000E+00    2
   0.1700000E+03  0.1400000E+03    3
   0.2400000E+03  0.1400000E+03    2
   0.2400000E+03  0.2220000E+03    2
   0.1700000E+03  0.2220000E+03    2
   0.1700000E+03  0.1400000E+03    2
   0.2640000E+03  0.1520000E+03    3
   0.2880000E+03  0.1520000E+03    2
   0.2880000E+03  0.2400000E+03    2
   0.2640000E+03  0.2400000E+03    2
   0.2640000E+03  0.1520000E+03    2
```

Figure 12. PLTBND file of the 3–D example generated by *PLTDSP*.

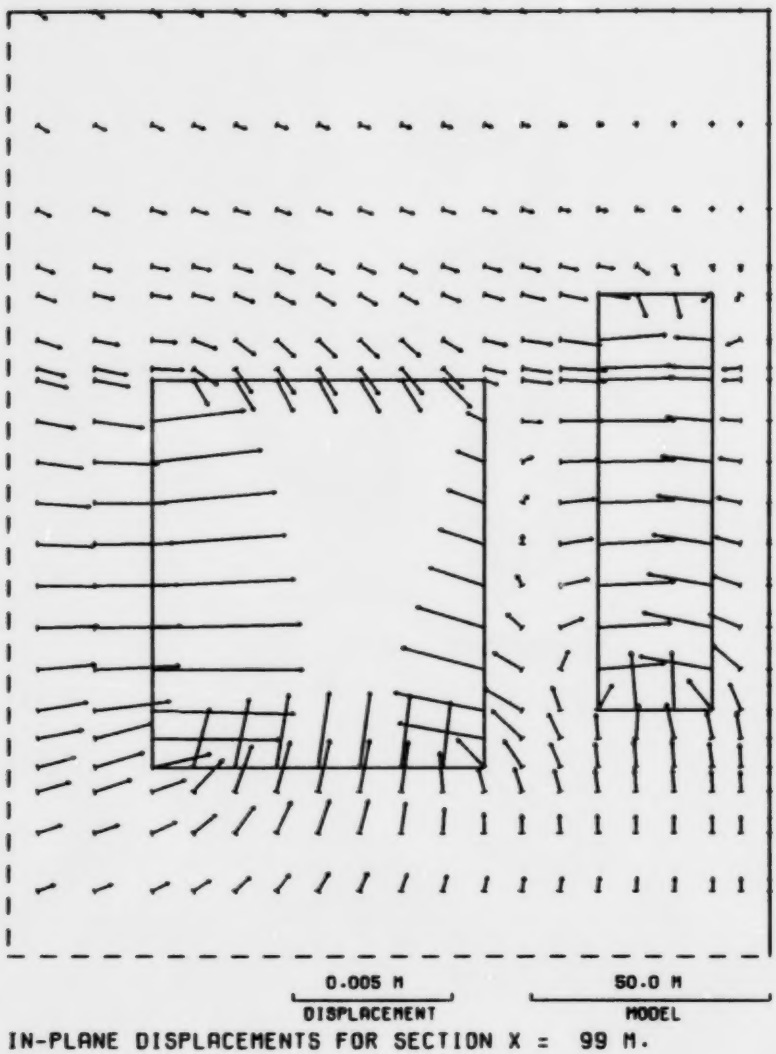


Figure 13. In-plane displacements plot of the 3–D example for section X = 99 m

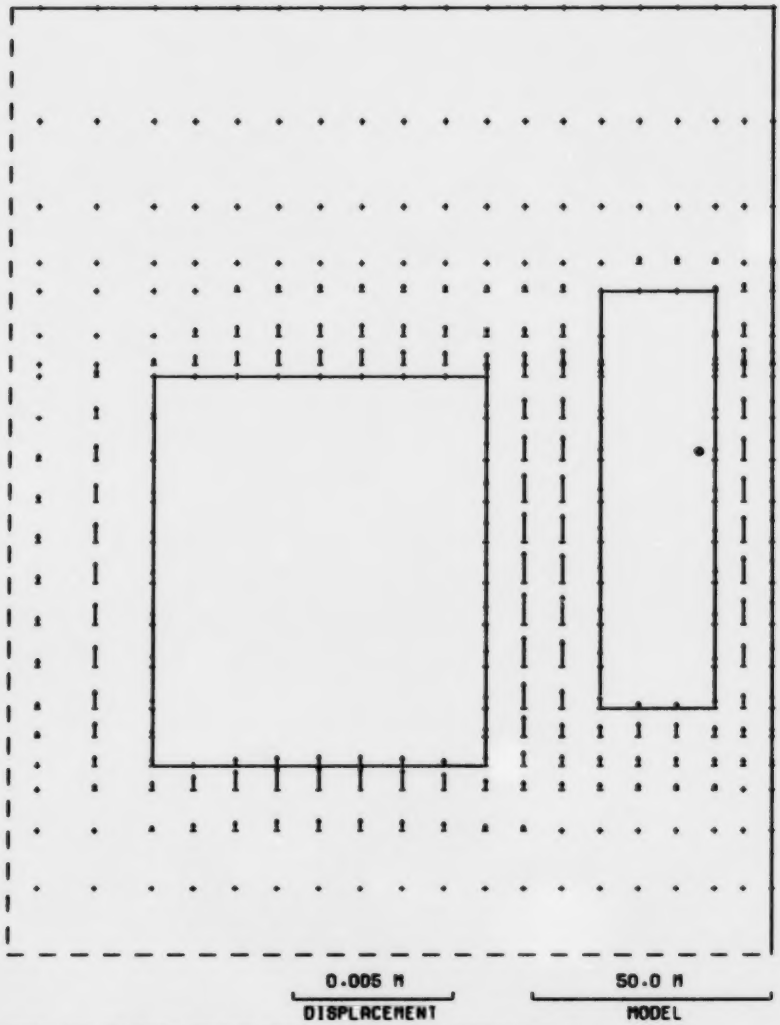


Figure 14. Out-of-plane displacements plot of the 3–D example for section X = 99 m

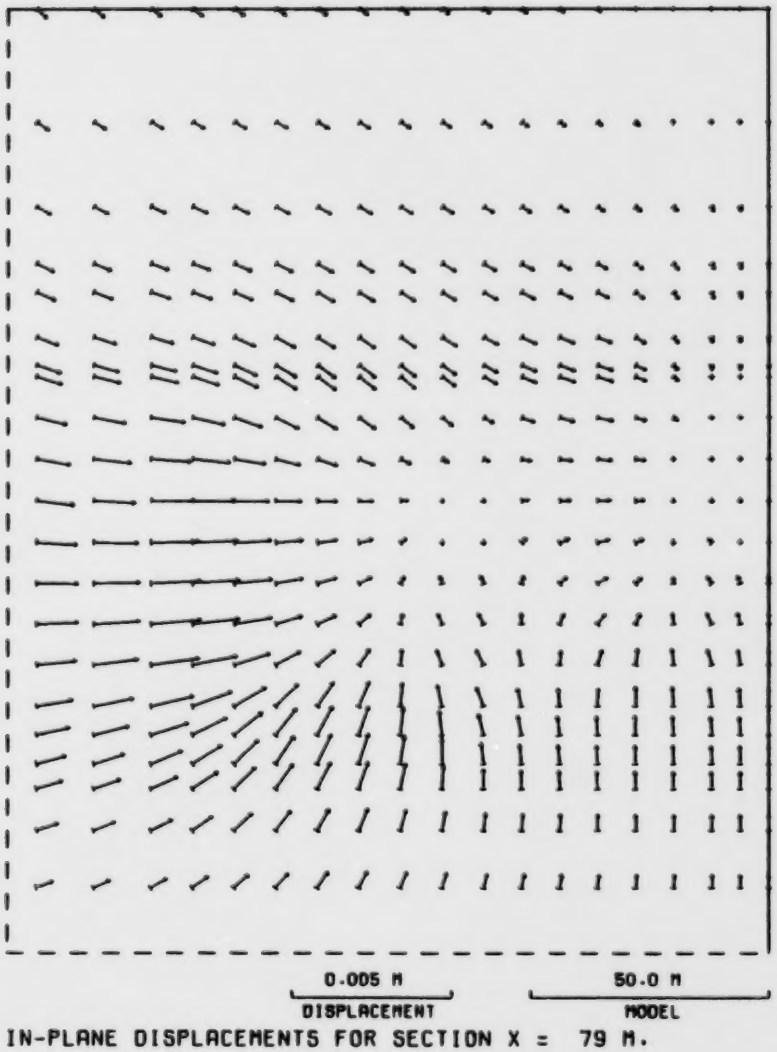


Figure 15. In-plane displacements plot of the 3–D example for section X = 79 m

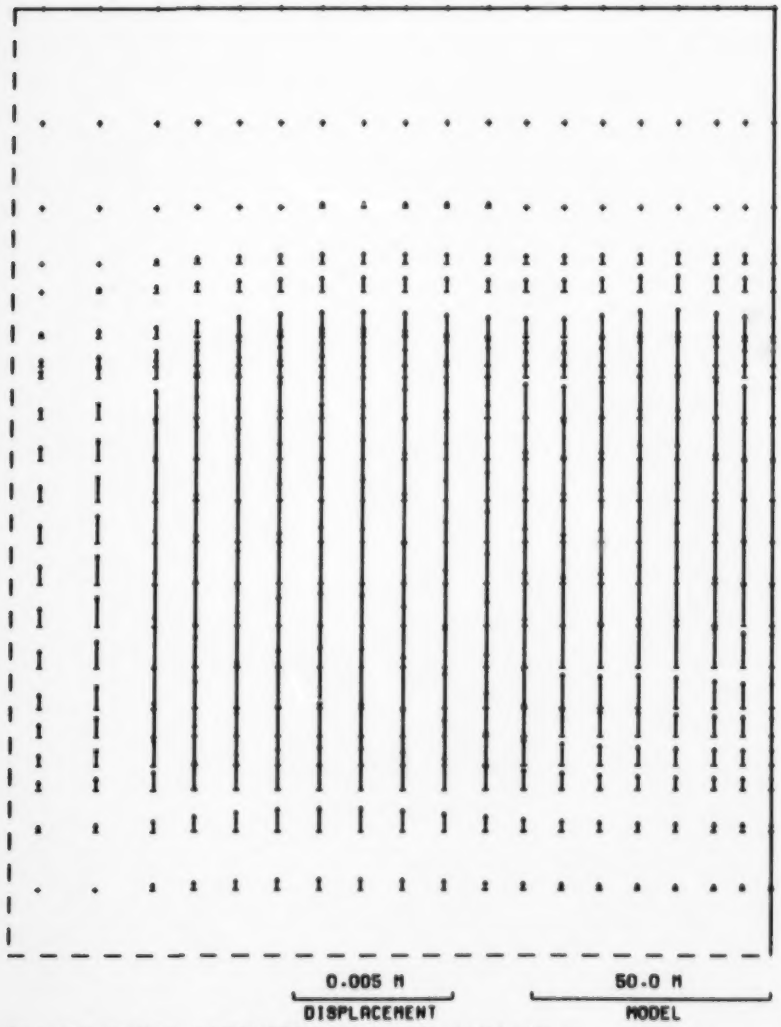


Figure 16. Out-of-plane displacements plot of the 3–D example for section X = 79 m

7.0 REFERENCES

1. Walden W.E.; Documentation of two SAP3D post-processors; Report MRP/MRL 76–8 (TR); Mining Research Laboratories, CANMET, Energy, Mines & Resources Canada; Ottawa; January 1976.

2. Yu, Y.S., Toews, N.A., Wong, A.S. and Morrison, H.D.; MRLPLT user's guide – A general purpose program for graphical representation of data over 2–D regions (VAX–11/750 version); Division Report MRL 88–97 (TR); Mining Research Laboratories, CANMET, Energy, Mines & Resources Canada; Ottawa; August, 1988.

3. Toews, N.A., Wong, A.S. and Yu, Y.S.; SAP3D documentation – A 3–D linear elastic finite element program (CRAY–1S Version); Division Report MRL 89–7 (TR); Mining Research Laboratories, CANMET, Energy, Mines & Resources Canada; Ottawa; March 1989.

4. Toews, N.A., Yu, Y.S. and Wong, A.S.; GEN3D user's guide – A three–dimensional mesh generating/plotting system for SAP3D (VAX–11/750 version); Division Report MRL 88–103 (TR); Mining Research Laboratories, CANMET, Energy, Mines & Resources Canada; Ottawa; December, 1988.